INSTRUMENT SHOP

POWER SUPPLY
INSTRUCTION MANUAL

FS-29-23-P.M.

NJE
PO Box 50, Culver Road
Dayton, N.J. 08810
(201) 329-4611
TWX: 710-480-5674

INSTRUMENT SHOP

INSTRUCTION
&
MAINTENANCE
HANDBOOK

FS SERIES
POWER SUPPLY

FS 29-23-P.M.

MODEL NUMBERS

FS6 - 46.0
FS8 - 43.0
FS10 - 41.0
FS12 - 40.0
FS15 - 35.0
FS18 - 32.0
FS20 - 30.0
FS24 - 25.0
FS29 - 23.0
FS33 - 21.0
FS37 - 19.0
FS43 - 17.0
FS48 - 16.0

NJE CORPORATION
Electronic Development & Manufacturing

NJE CORPORATION
20 BOBRIGHT AVENUE, KENILWORTH, NEW JERSEY 07033
A SUBSIDIARY OF CONDEC CORPORATION

WE guarantee that all power supplies formerly manufactured by Consolidated Avionics and now included in the product lines of NJE Corporation will continue without change in design, manufacture, quality assurance, warranty and delivery, except where such changes in the future would constitute normal improvements.

Theodore Matthew

THEODORE MATTHEW GENERAL MANAGER V P
NJE Corporation

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WARNING

This unit operates from an AC line source. Be careful to avoid contact with Input Power Terminals at all times.

Care must be taken to connect this voltage to the proper terminals or damage to unit will occur.

While unit is protected against external shorts, internal shorts may damage unit; therefore, care must be taken to keep cover on while unit is operating.

Before operating, or attempting any maintenance or repair of this unit . . . . read this Handbook carefully.

THE INFORMATION CONTAINED IN THIS HANDBOOK IS EXPLICITLY INTENDED FOR THE OPERATION AND MAINTENANCE OF CONSOLIDATED AVIONICS POWER SUPPLIES, AND IS NOT TO BE USED OR OTHERWISE REPRODUCED, FOR ANY OTHER PURPOSE, WITHOUT WRITTEN CONSENT OF CONSOLIDATED AVIONICS.

A. Introduction

1. This handbook contains all the information necessary for the installation, operation and maintenance of the Consolidated Avionics "FS" Series Power Supply. It is recommended that the appropriate sections of this Handbook be read carefully prior to installation, operation and maintenance.

2. The "FS" model is a completely solid-state AC-to-DC power source using "Worst Case" design techniques to provide a regulated output voltage. Rugged construction, use of high quality components and easy accessibility for service and maintenance make this model desirable for long service where reliability and performance are of primary consideration.

B. Complete Specifications

Complete electrical specifications are provided in Table 1 enclosed at the end of this Handbook.

C. Definition of Specifications

This section will familiarize the user with the nomenclature necessary for understanding the operation and the evaluation of this power supply.

1. Load Regulation

Load regulation is defined as the change in output voltage (line voltage held constant) as the load is varied from 0 to maximum current, i.e.:

$$\% \text{ Load Regulation} = \frac{\Delta E_o}{E_o} \times 100\% \text{ with } E_{in} = \text{Constant}$$

This reading should be taken at the sensing terminals

(3 and 4) with an accurate DC null type voltmeter.

2. Line Regulation

Line regulation is defined as the change in output voltage (load current held constant) as the line voltage is varied from 105VAC to 125VAC, i.e.:

$$\% \text{ Line Regulation} = \frac{\Delta E_o}{E_o} \times 100\% \text{ with } I_o = \text{Constant}$$

This reading should be taken at the sensing terminals (3 and 4) with an accurate DC null type voltmeter.

3. Ripple

Ripple is defined as the RMS amplitude of the AC voltage superimposed on the DC voltage at the output of the power supply. This measurement should be made at the sensing terminals (3 and 4) with an RMS measuring instrument.

4. Transient Response

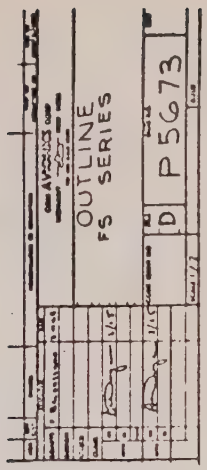
Transient response or Recovery. When a transient load condition is applied to any power supply, the output voltage will undershoot the value that would be obtained under static conditions. The time that is required for the output to recover 63% from its maximum amplitude is defined as the response time.

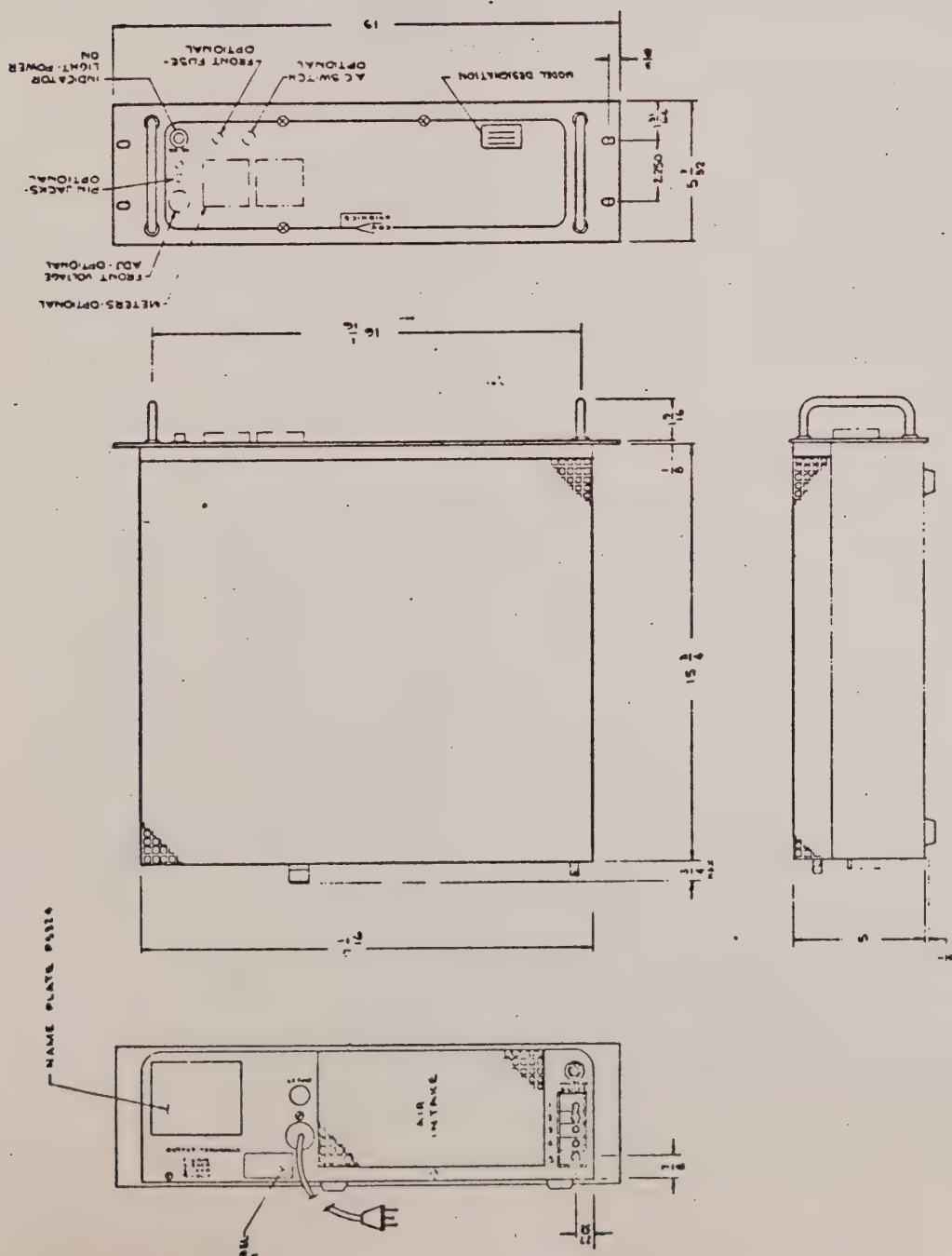
5. Temperature Coefficient

Temperature Coefficient is defined as the change of the output voltage due to a variation in ambient temperature after the effects of warm up drift are removed. The temperature coefficient is dimensioned $\%/^{o}C$.

D. Operating Instructions

1. Outline Drawing





2. Installation

No preliminary inspection or processing of the power supply is required. The unit is ready for operation when shipped from Consolidated Avionics.

3. a. Mounting

The "FS" series power supply has been designed for either bench use or to be incorporated as part of a system. Each unit is provided with four rubber feet mounted on the underside of the chassis and should be left this way for bench use. For incorporation into a system the rubber feet may be removed enabling the supply to be rack mounted. Care must be taken to insure that no restrictions are placed near the intake and exhaust air parts of the supply. The "FS" power supply is provided with a 5¼" high standard 19" panel.

b. External Connections

1	$C1^+$
2	+ out
3	+ sen
4	- sen
5	- out

1. Turning on Unit

Insert line cord (provided with unit) to a 115 V±10 V, 47 to 63 CPS line. No warm-up time is required to place unit into operating condition.

2. Connecting the load

The load is connected to terminals 2 and 5 if the load is located near the power supply. It should be noted that when the load is connected in this manner the voltage and regulation obtained at the load depends to a large extent on the drop in the wire leading to it. Therefore, care must be taken to see that the wire is large enough to prohibit a large voltage drop. When the load regulation obtained by direct connection is not satisfactory for a particular application, the full regulation capability of the equipment can be realized at the load by the use of remote sensing. See paragraph e if this mode of operation is to be used.

c. Fusing

The input AC fuse is located at the rear of the supply within easy access. Care should be taken to use the correct fuse or damage may result.

d. Controls

The unit is equipped with an output voltage control, located at the rear of the power supply. The control shaft is slotted for screw driver adjust.

e. Remote sensing

1. The Consolidated Avionics power supply is delivered with jumper wires installed for local

sensing. This mode of operation will be satisfactory for most applications.

If the load is located remotely from the power supply and the full regulation capability of the equipment is required, then it will be necessary to use remote sensing.

2. Remote sensing is accomplished by removing the jumper wires from terminals 2 through 5. Individual wires should be run from terminals 4 and 5 to the negative side of the remote load and from terminals 2 and 3 to the positive side of the remote load. For best ripple characteristic use a twisted shielded pair for the DC sensing lines.

CAUTION: The power supply can be damaged if the remote sensing terminals are reversed. Therefore be absolutely certain that the terminals are connected as indicated above before turning the power supply on.

f. Maintenance

The Consolidated Avionics "FS" series power supplies have been designed using "Worst Case" analysis techniques, and therefore can be expected to provide long and trouble free service. All components have been derated for long and reliable life. However, if it is necessary to replace components, they are easily accessible. To remove power transistors, remove the

two collector screws and lift transistor out of socket.

g. Thermal Cutout

The "FS" power supply is provided with two groups of heat sinks. A group consists of two heat sinks, a thermal switch and a fan. One thermal switch is mounted internally on a heat sink group. The thermal switches are connected in series in one side of the line. If either heat sink group approaches a critical temperature due to either a fan failure or excess power, the contact will open thereby disabling the power supply.

E. Optional Features

Several standard optional features are offered with Con Avionics "FS" series power supplies. The options found in any individual unit can be identified by the suffix letters added to the model number.

1. Overvoltage Protection

1.1 Operation

The Overvoltage Protection circuit employs a silicon controlled rectifier (SCR) to short the output of the power supply. An increase in output voltage across a preset voltage divider fires the SCR, thereby opening the circuit breaker provided in the overvoltage circuit. To reset the protective circuit, the AC input power must be removed, the overvoltage fault corrected, and the circuit breaker reset.

1.2. Connections

To employ the Overvoltage Protection Module, the following connections must be made:

a. Remove jumper between TB1-2 and TB1-3 (+out to +sens) as well as jumper between TB1-4 and TB1-5 (-sens to -out) of power supply.

b. Connect wire from TB1-2 (+out) of supply to terminal 5 of OVP Barrier Strip.

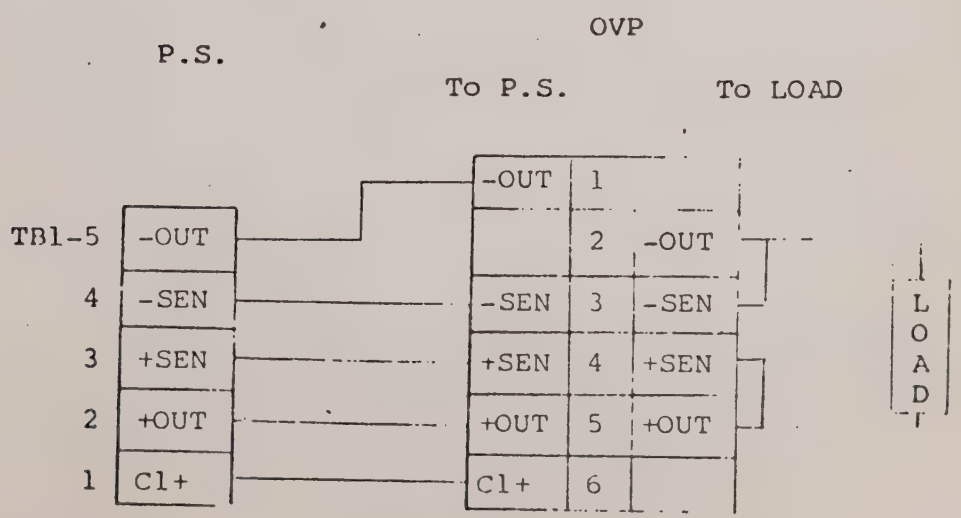
c. Connect wire from TB1-5 (-out) of supply to terminal 1 of OVP Barrier Strip.

d. Connect wire from TB1-3 (+sens) of supply to terminal 4 of OVP Barrier Strip.

e. Connect wire from TB1-4 (-sens) of supply to terminal 3 of OVP Barrier Strip.

f. Connect wire from TB1-1 (C1+) of supply to terminal 6 of OVP Barrier Strip.

g. The load is connected to terminals 2 and 5 on the OVP Barrier Strip.



1.3. Remote Sensing

For remote sensing, the same connections as listed above exist between the power supply and the OVP Barrier Strip. However, the jumper between terminals 2 and 3 as well as 4 and 5 on the load side of the OVP Barrier Strip must be removed (-out to -sens and +out to +sens). A wire is now connected from terminal 4 of the OVP to the plus (+) side at the load and another wire from terminal 3 of the OVP to the minus (-) side at the load. Because of lead length from the supply to the load, it may be necessary to add some capacity at the output of the power supply. This may be required in order to suppress any noise or tendency to oscillate that would affect the operation of the supply.

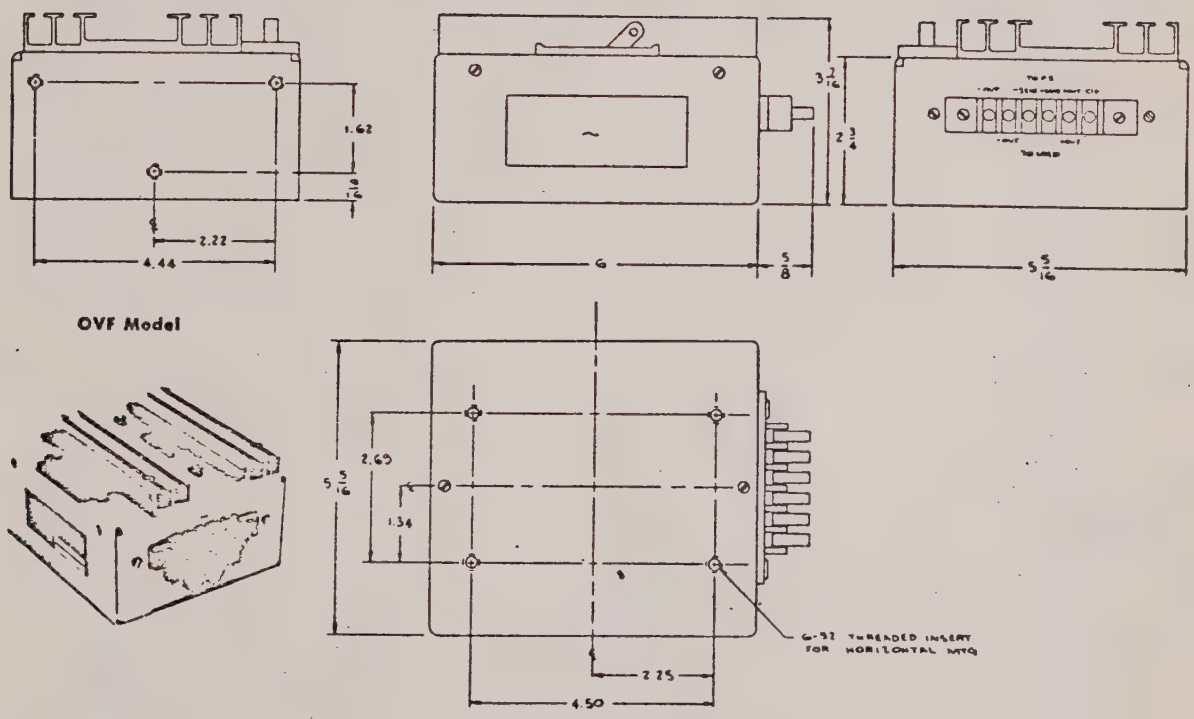
1.4. Adjustment

The overvoltage trip point is preset at the factory. In the event that readjustment becomes necessary, the following procedure should be used:

a. Apply a voltage 120% above output voltage of supply to terminals 5 and 1 (+out and -out) of OVP.

b. Adjust potentiometer R1 of OVP until the circuit breaker opens.

NOTE: In order to prevent damage to the SCR, the current capability of the external source must be limited to 2.0 Amps for the 6 and 8 Volt supplies, and 4.0 Amps for all supplies above 8 Volts.



OUTLINE DRAWING OVF

2. Meters (Suffix letter "M")

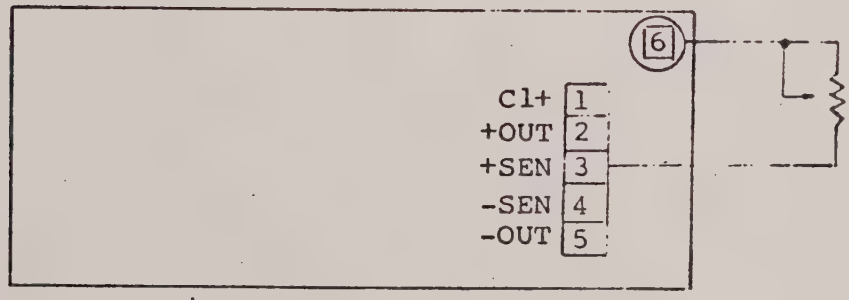
A voltage and current meter are mounted on the front panel when so specified. The meters supplied are accurate to 2% of full scale at 25°C.

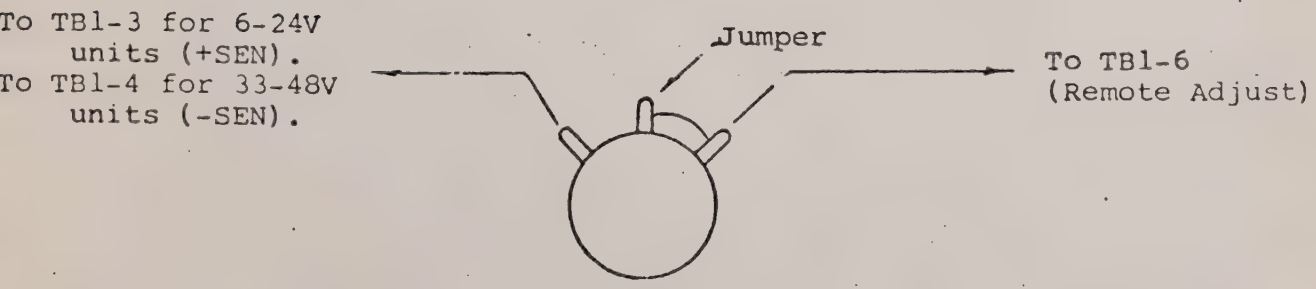
3. Front Panel Controls (Suffix letter "P")

All controls are mounted on the front panel when so specified. The controls provided are: AC on-off switch, AC fuse, pilot light, voltage adjustment potentiometer, and output voltage test points.

4. Remote Voltage Adjustment (Suffix letter "R")

For remote voltage adjustment applications, the voltage adjusting potentiometer is connected as shown below.





Pot value for 6V supply is 200Ω.
Pot value for 8V thru 48V is 500Ω.

5. Epoxy Coating (Suffix letter "E")

A black epoxy coating can be furnished on the FS power supply. This coating completely covers all components on the printed circuit board.

F. General Circuit Theory

A DC voltage is developed at the output of the full wave rectifiers CR2 and CR3. The input capacitor C1 is used to reduce the inherent ripple due to rectification.

The pass section functions as a variable element in series with the input and output circuits, taking up the differences between the input and output voltage. Since this section passes the total load current, high dissipation results and consequently, junction temperature is of prime importance. To safely maintain this power under all conditions, the pass section is comprised of 12 transistors in parallel. In this manner, the total power is shared equally by 12 transistors. The pass transistors are controlled by base current which, in turn, is controlled by the base current of driver transistors Q2, Q3, Q7, Q8, and Q9. The drivers are connected in a Darlington configuration. With this connection, a saving of components as well as a reduction of signal degeneration can be realized. The base of Q3 is controlled by the collector of Q4 which is the output of a differential amplifier. The differential amplifier operates by sampling the change in output voltage by means of a resistive divider string connected at the output, and comparing this change to a fixed reference

voltage obtained from zener diode CR4. If the change in output voltage is such as to signal transistor Q4 on, then the base current of Q4 will be amplified through the driver stages and pass section. The base current of Q4 is very small and is indicative of the dynamic gain of the circuit which is in the order of 2×10^8. For example, a .0.1μa change in the base of Q4 will produce a total load change of 40 amperes of approximately 3 amperes per pass transistor. Thus, it follows that the smaller the base current of Q4, the better the regulation.

Overload Protection

The DC current limit point of the FS Power Supply is controlled by means of internally mounted Potentiometer R9. This potentiometer is permanently set and the electrical position of the wiper should not be changed. The operation of the current limit circuit is as follows: A current monitoring resistor R1 is placed in series with each transistor in the pass section. Resistors R26 through R37 are used as a current summing network to provide a preset reference voltage across potentiometer R9. Transistor Q5 will be turned "on" when it senses a positive voltage difference between the monitoring resistor and the preset reference voltage in excess of 0.5 volts. Thus, the transistor applies a control signal to the drivers, limiting the current through the pass section.

Series Start Operation

When series connecting the "FS" Power Supply with another supply, provision has been made to prevent lock-up of one

supply by the other at turn-on. This is accomplished by using an RC network, (R23 and C8) to provide the necessary time delay during which time the overload circuit is disabled. Thus, both supplies are permitted to attain full output voltage (See Table 2).

G. Troubleshooting Guide

SYMPTOM	PROBABLE CAUSE and/or REMEDY
1. No DC Output	a. Check loading of supply. A heavy overload or short-circuit may have activated the current limit circuitry.
	b. Check thermal overload circuit. If ambient temperature is too high, one of the fans has failed or air flow is impeded, the thermal cutout will shut down the supply.
	c. Check if overvoltage circuit has been activated due to overvoltage condition.
	d. Check raw DC from the collector of the pass transistors to common. If there is no voltage, check fuse F1, transformer T1, and power rectifiers CR2 and CR3 for proper operation.
	e. If the raw DC voltage exists between collector and common, the trouble lies in the amplifier section. Check the pass transistors for short or open circuit. To check the driver stages, saturation or turn off of the transistor can be simulated by shorting the emitter to collector (saturation) or removing the transistor (turn-off). Since the drivers are emitter coupled, there will be no phase inversion, and if the transistor is removed, the output voltage will fall to almost zero volts. If the transistor is saturated, the output voltage will rise. Note that if the supply is protected from overvoltage (optional feature), the overvoltage circuit must be disconnected for the above test.

Troubleshooting Guide (Con't.)

SYMPTOM		PROBABLE CAUSE and/or REMEDY
		To check the differential amplifier Q4 and Q6, the same method as outlined above may be used. However, phase inversion must be kept in mind.
2. Excessive Ripple	a.	Check power transistors Q1A through Q1M for short circuit.
	b.	If the AC on the output is higher than the specified value, unit may be oscillating. Check capacitors C3, C4, C7, C11 and C12 for open or short.
	c.	If the AC on the output is not high frequency but close to the input line frequency, capacitors C1 and C2 may be open or rectifier diodes may be damaged.
	d.	Check zener diode CR4 for similar waveshape as appears on output.
3. No Regulation	a.	Check for possible improper load conditions which may be activating current limit circuit.
	b.	Check transistors for short or open circuits.
	c.	Check zener diode CR4 for proper voltage.
	d.	Check resistors or potentiometers for open or short circuits.
4. Erratic Output Voltage	a.	Using an oscilloscope, check to see whether zener diode CR4 is noisy.
	b.	Check for intermittent open circuit.
5. Supply Current Limits Before Full Load is Reached	a.	Adjustment of potentiometer R9 may not be correct.
	b.	If Q5 has been changed, the operating point at the current limit will be

Troubleshooting Guide (Con't.)

SYMPTOM	PROBABLE CAUSE and/or REMEDY
	different and consequently, potentiometer R9 must be readjusted.

H. Alignment Procedures

The alignment procedures pertain to current limit pull-in Potentiometer R9 and Reference Current Potentiometer R6. The potentiometers are permanently set and should be realigned only if replacement is required.

Potentiometer R6 Adjustment:

1. Turn on power supply and adjust input voltage to 115 VAC with supply unloaded.
2. Turn voltage adjust Potentiometer R5 to fully CCW (shorting R5).
3. Adjust Potentiometer R6 for minimum output voltage as per electrical specifications less an additional 100 millivolts.
4. Secure position of R6 with Loctite Sealant or equivalent.
5. Readjust Potentiometer R5 to desired output voltage.

Potentiometer R9 Adjustment:

1. Turn on power supply and adjust input voltage to 105 VAC and output to full load current.
2. Turn voltage adjust Potentiometer R5 CCW for minimum output voltage.
3. By changing the applied load, increase output current to 115% of its rated full load value.
4. Carefully adjust Potentiometer R9 until output current begins to drop. Back off and recheck this point.

5. Having obtained current threshold point, secure position of R9 with Loctite Sealant or equivalent.
6. Readjust output current to its full load value.
7. Readjust potentiometer R5 to desired output voltage.

I. ELECTRICAL SPECIFICATIONS

Input:	105-125 VAC, 47-63 cps
Regulation (Line and Load combined):	±0.05%
Ripple:	1 millivolt RMS maximum
Response:	25 microseconds typical, 40 microseconds maximum
Temperature Coefficient:	0.015%/°C or 1.8 MV/°C, whichever is greater
Temperature:	75°C maximum (using derated output currents as specified below)

TABLE 1

MODEL NUMBER	VOLTAGE RANGE	OUTPUT CURRENT @ 55°C	DERATED OUTPUT CURRENT @ 75°C
FS6-46.0	5.5-6.5	46.0	38.0
FS8-43.0	7.0-9.0	43.0	36.0
FS10-41.0	9.0-11.0	41.0	35.0
FS12-40.0	11.0-13.0	40.0	33.0
FS15-35.0	14.0-16.0	35.0	30.0
FS18-32.0	17.0-19.0	32.0	29.0
FS20-30.0	19.0-21.0	30.0	28.0
FS24-25.0	22.0-26.0	25.0	21.5
FS29-23.0	27.0-31.0	23.0	20.0
FS33-21.0	31.0-35.0	21.0	18.5
FS37-19.0	35.0-39.0	19.0	16.5
FS43-17.0	41.0-45.0	17.0	15.0
FS48-16.0	45.0-51.0	16.0	14.0

TABLE 2

This list represents the maximum external capacity which may be placed at the output terminals of each individual supply if the power supply is to be operated in series with another power supply.

MODEL NUMBER	CAPACITY MFD.
FS6-46.0	10,000
FS8-43.0	10,000
FS10-41.0	10,000
FS12-40.0	10,000
FS15-35.0	10,000
FS18-32.0	10,000
FS20-30.0	5,000
FS24-25.0	5,000
FS29-23.0	4,000
FS33-21.0	3,000
FS37-19.0	3,000
FS43-17.0	2,000
FS48-16.0	2,000

J. WARRANTY

Seller warrants each instrument manufactured or sold by it to meet its published specifications and to be free from defects in material and workmanship under normal use and proper operation and service. Its obligation under this warranty is limited to repairing or replacing F.O.B., its plant, any instrument or part thereof, which shall be returned to it with shipping charges prepaid prior to the end of the FIFTH YEAR after the date of shipment of the instrument involved and which, upon examination by seller, is reasonably determined to be defective. If seller reasonably determines that the instrument or part thereof is not defective or that the defects discovered are due to abnormal or improper use, operation or service, then the original purchaser will be notified and the repairs, if authorized, will be charged to such purchaser.

REPAIRS - If the instrument does not operate properly, seller is to be notified with a full description of the trouble and the model and serial number of the instrument. Upon receipt of the notification, seller will either send service instructions or a Return Repair Authorization. Upon receipt of a Return Repair Authorization, the instrument is to be forwarded, transporation charges prepaid, to seller. If the fault in the instrument is not covered by the warranty, an estimate of the repair costs will be forwarded upon request. All returned instruments should be packed in a substantial box surrounded by several inches of excelsior or other absorbing material.

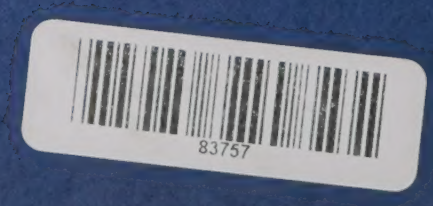
CLAIMS FOR DAMAGE INCURRED IN TRANSIT - As soon as the instrument is received, it should be tested. If it does not operate properly, or is damaged in any way, a claim should be filed with the carrier. Upon receipt of a full report of the damage, seller will advise what disposition is to be made of the equipment and arrange for repair or replacement. Please include model and serial number and the date of purchase when referring to any instrument.

The Company reserves the right to discontinue instruments without notice and to make modification in design at any time without incurring any obligation to make such modifications to instruments previously sold.

C1 A-F	P5214 (6)
C2	P4747
C3	112813
C4	CK62BX472K
C5	.5MFD 200V
C6	.5MFD 200V
C8	P5051
C9	P5190 (2)
C10	P4747
C12	CK62BX222K
C14	.22MFD 200V
CR1	P3924
CR2	25H20
CR3	25H20
CR4	P4281
CR5	P4685
CR6	IN457A
CR8	25H10
CR9	368B
CR10	368B
CR11	HC68
CR12	HC68
Q1 A-M	P5034 (12)
Q2	P4069
Q3	P3923
Q4	P3923
Q5	P3923
Q6	P3923
Q7	P3923
Q8	P5149
Q9	P3923
R1-A-M	1.3 ohm 5% 15W (12)
R2	5.1K 5% 1/2W
R3	1.2K 5% 2W
R4	1.5K 5% 5W
R5	500 ohm 10% Potietometer
R6	500 ohm 10% Potientometer
R7	240 ohm 5% 5W
R9	500 ohm 10% 1.5W Potientometer
R10	765 ohm 5% 5W
R12	4.3K 5% 1/2W
R14	820 ohm 5% 2W
R15	1.8K 5% 1/2W
R16	15K 5% 1/2W
R17	24K 5% 1/2W
R18	24K 5% 1/2W
R19	1.3K 5% 1W
R20	5 ohm 5% 30W
R22	2.2K 5% 1/2W
R23	1.5K 5% 1/2W
R25	60 ohm 5% 3W
R26-37	910 ohm 5% 1/2W (12)
R38	85 ohm 5% 20W
T1	P5232
S1	P5624
S2	P5624
F1	20 AMP

REV.	ECN	DATE	
A	B-0557	8/28/72	W/I

MODEL FS 29-23.0
RATING 29 V-23.0 A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